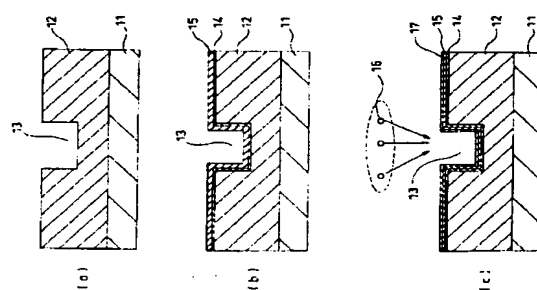


(43)公開日 平成9年(1997)7月22日

(54)【発明の名称】埋め込み配線形成方法[illegible]

【本発明は、半導体集積回路装
 置の構成に関する技術分野】
 本発明は、半導体集積回路装
 置の製造工程等において、絶縁層に形成された凹部、溝、空
 洞部、配線用金属を埋め込んで埋め込み配線層を形成す

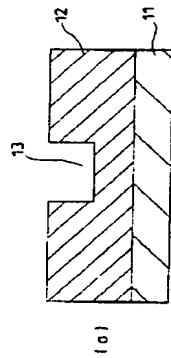
【0008】そこで、絶縁膜に於けるA線形成領域に、四

の導電膜を形成することができる

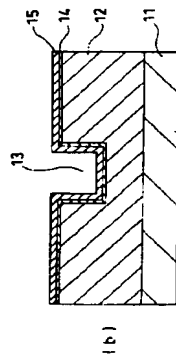
【図面の簡単な説明】

- 【図1】本発明の一実施形態に係る埋込み配線形成方法の各工程を示す断面図である
 【図2】本発明の一実施形態に係る埋込み配線形成方法の各工程を示す断面図である
 【図3】本発明の一実施形態に係る埋込み配線形成方法のプラズマ酸化工程において酸素イオンが酸素分子と衝突する状態を示す概念図である
 【図4】本発明の一実施形態に係る埋込み配線形成方法に用いるアンロードカップリング電圧プラズマ装置の概略構成図である
 【図5】本発明の一実施形態に係る埋込み配線形成方法のプラズマ酸化工程における処理下カドとタンクステン膜中の拡散した銅濃度との関係を示す特性図である

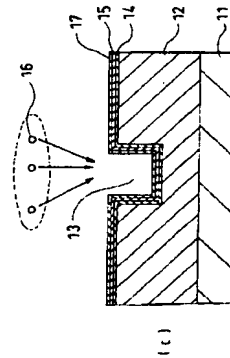
【図1】



(a)

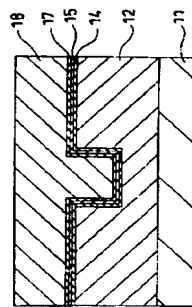


(b)

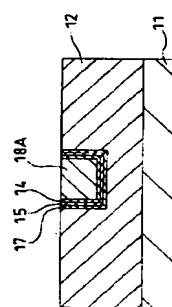


(c)

【図2】



(a)



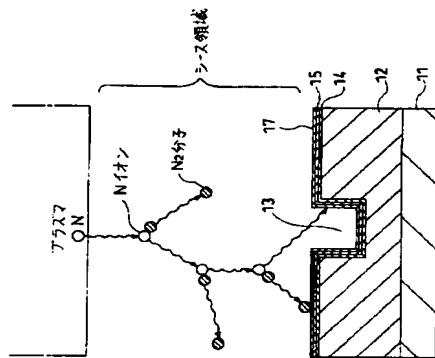
(b)

【図6】従来の埋込み配線形成方法の問題点を説明する断面図である

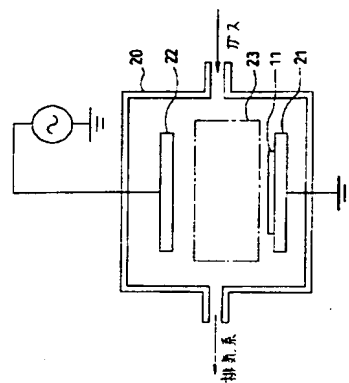
【符号の説明】

- 11 シリコン基板（半導体基板）
 12 シリコン酸化物膜（絶縁膜）
 13 凹状溝（凹部）
 14 チタン膜
 15 タンクステン膜（第1の導電膜）
 16 酸素イオン
 17 酸化タンクステン膜（第2の導電膜）
 18 銅膜（金属膜）
 20 真鍮層
 21 試料台
 22 対向電極
 23 プラズマ領域

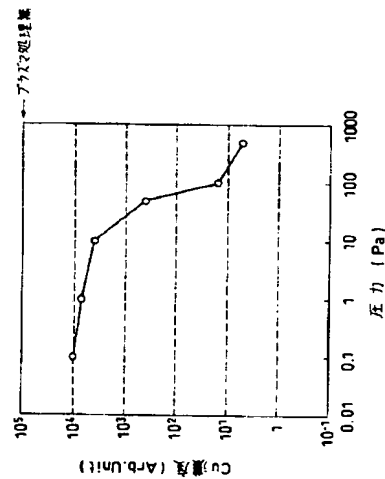
【図3】



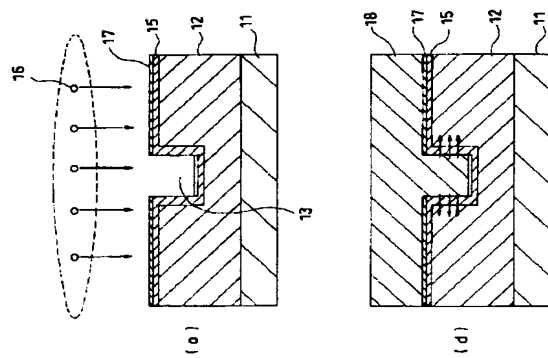
【図4】



【図5】



【図6】



PATENT ABSTRACTS OF JAPAN

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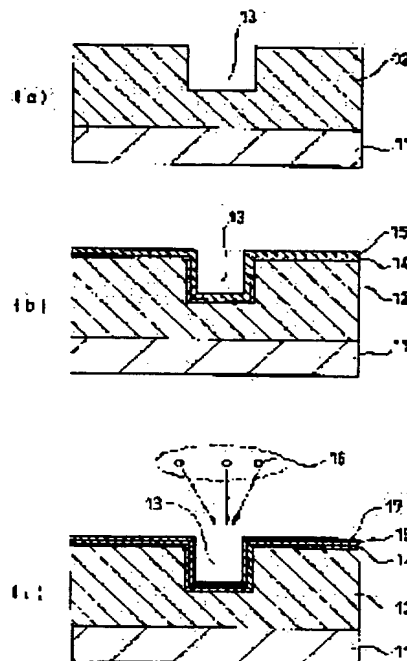
Priority number : 07292974 Priority date : 10.11.1995 Priority country : JP

(54) METHOD OF FORMING BURIED WIRING

(57)Abstract:

PROBLEM TO BE SOLVED: To surely form a nitride film of high fusing point conductive material also at the sidewall of the recess of a high fusing point conductive material film, though plasma nitrification is performed to the high fusing point conductive material film having a recess.

SOLUTION: A silicon substrate 11 where a silicon oxide film 12 having a recessed groove 13 is made on the surface is retained on a sample provided within a vacuum container, and then a titanium film 14 and a tungsten film 15 are stacked in order on the silicon oxide film 12. In condition that the interior of the vacuum container is kept at a pressure of 10Pa, the surface of the tungsten film 15 is nitrided by plasma to form a tungsten nitride film 17. On the tungsten nitride film 17, a copper film is accumulated on the tungsten nitride film 17, and then the titanium film 14, the tungsten film 15, and the tungsten nitride film 17, and the section positioned outside the recessed groove 13 in the copper film are removed to form a buried wiring consisting of copper.



LEGAL STATUS

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[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

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3. In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] The embedding wiring formation method characterized by providing the following. The 1st process which forms a crevice in the insulator layer on a semiconductor substrate. The 2nd process which forms the 1st electric conduction film which has a crevice in the part which consists of this high-melting point conductivity material, and corresponds with the crevice of the aforementioned insulator layer by depositing high-melting point conductivity material on the aforementioned insulator layer. The 3rd process which forms the 2nd electric conduction film which has a crevice in the part which consists of a nitride of the aforementioned high-melting point conductivity material, and corresponds with the crevice of the electric conduction film of the above 1st by holding the aforementioned semiconductor substrate and carrying out the plasma nitriding of the surface section of the electric conduction film of the above 1st into the vacuum tub maintained at the pressure of 10Pa or more. the electric conduction film top of the above 2nd -- wiring -- public funds -- a group -- the crevice of the electric conduction film of the above 2nd -- the aforementioned wiring -- public funds -- by depositing so that a group may be embedded the aforementioned wiring -- public funds -- the portion located in the outside of the crevice of the aforementioned insulator layer in the 4th process which forms the metal membrane which consists of a group, the electric conduction film of the above 1st, the 2nd electric conduction film, and a metal membrane -- removing -- the inside of the crevice of the electric conduction film of the above 2nd -- the aforementioned wiring -- public funds -- the 5th process which consists of a group and which embeds and forms wiring

[Claim 2] The 3rd process of the above is the embedding wiring formation method according to claim 1 characterized by including the process which holds the aforementioned semiconductor substrate and carries out the plasma nitriding of the surface section of the electric conduction film of the above 1st into the aforementioned vacuum tub maintained at the pressure of 50Pa or more.

[Claim 3] the wiring in the 4th process of the above -- public funds -- the embedding wiring formation method according to claim 1 characterized by a group being copper or a copper alloy

[Claim 4] The high-melting point conductivity material in the 2nd process of the above is the embedding wiring formation method according to claim 1 characterized by being titanium, a tantalum, or a tungsten.

[Claim 5] The 3rd process of the above is the embedding wiring formation method according to claim 1 characterized for including the process which performs plasma nitriding where the aforementioned semiconductor substrate is held to ground potential or right potential by things.

[Claim 6] The 2nd process of the above is the embedding wiring formation method according to claim 1 characterized by including the process which deposits the aforementioned high-melting point conductivity material by CVD.

[Claim 7] The 2nd process of the above is the embedding wiring formation method according to claim 6 characterized by including the process in which a part of this high-melting point conductivity material [at least] forms the electric conduction film of the above 1st in the amorphous state by depositing this high-melting point conductivity material in the temperature field in which crystallization of the aforementioned high-melting point conductivity material is suppressed.

[Translation done.]

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3. In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] crevices, such as a concave slot where this invention was formed in the insulator layer in the manufacturing process of semiconductor integrated circuit equipment etc., -- wiring -- public funds -- the method of embedding and embedding a group and forming wiring -- being related -- especially -- wiring -- public funds -- it is related with the technology of preventing the situation which a group oxidizes or is diffused in an insulator layer

[0002]

[Description of the Prior Art] the wiring used for semiconductor integrated circuit equipment etc. now -- public funds -- the copper or the copper alloy resistance excels [copper alloy] in electromigration resistance low as compared with the aluminium alloy although an aluminium alloy is used in many cases as a group -- wiring of the next generation -- public funds -- promising ** is carried out as a group

[0003] The biggest technical problem to utilization of the copper wiring which consists of copper or a copper alloy is the processability over prevention of oxidization of copper wiring, prevention of diffusion into the insulating layer of copper wiring, and a copper film. Especially the copper or the copper alloy that constitutes copper wiring is SiO₂ used as a layer insulation film. In oxidizing with a film ****, it is SiO₂. Since it is easy to be spread in a film, there is a possibility of having a bad influence on devices, such as a transistor currently formed in the bottom of a layer insulation film. Then, forming various kinds of barrier layers between copper wiring and a layer insulation film is proposed.

[0004] N₂ [as opposed to / a Cu-Ti alloy / in JP,02-240920,A] under the temperature of 800 degrees C The method of preventing copper oxidization and copper diffusion is proposed by forming the barrier layer which performs annealing and consists of a TiN film.

[0005] Moreover, the method of forming the barrier layer which performs the plasma nitriding by the efficient consumer response plasma method to JP,06-275623,A, "Diffusion Barrier Properties of Transition Metals and Their Nitrides for Cu Interconnections" T. Nakao et al., and VMIC (1994) to W film, and is set to them from a nitriding tungsten film is proposed.

[0006]

[Problem(s) to be Solved by the Invention] By the way, N₂ [like the former method] under the temperature of 600 degrees C or less although it is necessary to hold down the temperature of heat treatment to a barrier layer to 600 degrees C or less in order to suppress oxidization and diffusion of a lower layer of copper wiring, when forming multilevel-metal wiring using the copper wiring which consists of copper or a copper alloy A TiN film cannot be formed in annealing. N₂ [on the other hand] under the temperature of about 800 degrees C if a TiN film is formed by annealing, oxidization of lower layer copper wiring and the problem of diffusion will occur. Therefore, N₂ The formation of a barrier layer and the adoption of copper wiring by annealing have the problem of being hard to be compatible.

[0007] Since the latter method can form a uniform barrier layer by low temperature and the problem of oxidization and diffusion of a lower layer of copper wiring does not arise, the formation of a barrier layer and the adoption of copper wiring by plasma nitriding are compatible. However, it is very difficult copper unlike aluminum, to perform dry etching to a copper film, since the halogenated compound is nonvolatile, and to form copper wiring.

[0008] Then, after forming a concave slot in the wiring formation field in an insulator layer, a copper film is formed so that the whole surface may be covered, copper may be deposited and copper may be embedded in a concave slot, and the method of embedding and forming wiring which removes the portion of the outside of the concave slot in a copper film, and consists of copper is proposed after that.

[0009] By the way, when forming copper wiring by the embedding wiring formation method, you have to form a barrier layer not only in the pars basilaris ossis occipitalis of a concave slot but in the side-attachment-wall section. In JP,06-275623,A, as mentioned above, after depositing a metal on the pars basilaris ossis occipitalis and the side-attachment-wall section of a concave slot and forming a metal membrane, by performing the plasma nitriding by the efficient consumer response plasma method to this metal membrane, the barrier layer which consists of a nitride of the aforementioned metal is formed, and the processing pressure force at this time is set to 1mTorr.

[0010] However, there is a problem as shown in drawing 6 (a) and (b) in the conventional method of forming the barrier layer which performs plasma nitriding in 1mTorr and consists of a metal nitride. Drawing 6 (a) forms the concave slot 13 in this silicon oxide 12, after depositing a silicon oxide 12 on a silicon substrate 11, next after it covers the whole surface and deposits the tungsten film 15 on a silicon oxide 12, it shows the process which forms the nitriding tungsten film 17 in the front face of the tungsten film 15 by plasma nitriding. In this case, possibility that nitrogen ion will collide with a nitrogen content child in a sheath field since the average free process of the nitrogen ion in 1mTorr is 10cm or more and it is quite large compared with the sheath length (about 3mm) of the sheath field between a plasma generating field and a silicon substrate is a low very much. For this reason, as shown in drawing 6 (a), incidence of the nitrogen ion 16 is carried out from an almost perpendicular direction to a silicon substrate 11. Therefore, since the nitrogen ion 16 hardly reaches the side-attachment-wall section of the concave slot 13 in the tungsten film 15 and a nitriding reaction is not promoted in the side-attachment-wall section of the concave slot 13 of the tungsten film 15, the nitriding tungsten film 17 will be formed in the side-attachment-wall section of the concave slot 13.

[0011] In the state where the nitriding tungsten film 17 is not formed in the side-attachment-wall section of the concave slot 13 in the tungsten film 15 If the whole surface is covered and a copper film 18 is deposited, as shown in drawing 6 (b), since the tungsten film 15 does not have sufficient barrier nature to a copper film 18 A copper film 18 is diffused in a silicon oxide 12 through the side-attachment-wall section of the concave slot 13 in the tungsten film 15, and has the problem of

having a bad influence on the device formed on the silicon substrate 11.

[0012] Moreover, although it is desirable that the coverage to the pars basilaris ossis occipitalis and the side-attachment-wall section of a concave slot carries out by good CVD as for the process which deposits a refractory metal on the pars basilaris ossis occipitalis and the side-attachment-wall section of the concave slot mentioned above, and forms a metal membrane, there are the following problems in this case. namely, -- low -- if the crystal growth of the refractory metal deposited to form a metal membrane [****] is promoted, in case irregularity will be made on the surface of a metal membrane and plasma nitriding treatment of the metal membrane will be carried out, the part to which nitriding progresses with the irregularity on the front face of a metal membrane, and an overdue part occur For this reason, there is also a problem that the barrier layer which consists of a metal nitride nitrided uniformly is not obtained.

[0013] In spite of performing plasma nitriding to the electric conduction film which consists of high-melting point conductivity material into which this invention has a crevice in view of the above, it aims at the nitride of high-melting point conductivity material being certainly formed also in the side-attachment-wall section of the crevice in this electric conduction film.

[0014]

[Means for Solving the Problem] If plasma nitriding is performed to the electric conduction film which becomes the bottom of the pressure of 10Pa or more from high-melting point conductivity material, this invention will find out that nitrogen ion also reaches the side-attachment-wall section of the crevice in this electric conduction film, and this electric conduction film is nitrided certainly, and will constitute it based on this knowledge.

[0015] The solution means which invention of a claim 1 provided concretely The 1st process which forms a crevice in the insulator layer on a semiconductor substrate for the embedding wiring formation method, and by depositing high-melting point conductivity material on the aforementioned insulator layer The 2nd process which forms the 1st electric conduction film which has a crevice in the part which consists of this high-melting point conductivity material, and corresponds with the crevice of the aforementioned insulator layer, By carrying out the plasma nitriding of the surface section of the electric conduction film of the above 1st, where the aforementioned semiconductor substrate is held in the vacuum tub maintained at the pressure of 10Pa or more The 3rd process which forms the 2nd electric conduction film which has a crevice in the part which consists of a nitride of the aforementioned high-melting point conductivity material, and corresponds with the crevice of the electric conduction film of the above 1st, the electric conduction film top of the above 2nd -- wiring -- public funds -- a group -- the crevice of the electric conduction film of the above 2nd -- the aforementioned wiring -- public funds -- by depositing so that a group may be embedded The portion located in the outside of the crevice of the aforementioned insulator layer in the 4th process which forms the metal membrane which consists of the aforementioned metal for wiring, the electric conduction film of the above 1st, the 2nd electric conduction film, and a metal membrane is removed. the inside of the crevice of the electric conduction film of the above 2nd -- the aforementioned wiring -- public funds -- it considers as composition equipped with the 5th process which consists of a group and which embeds and forms wiring

[0016] The following phenomena arise by composition of a claim 1.

[0017] Average free process λ_{dai} of nitrogen ion Since it is in inverse proportion to the pressure P in a vacuum tub, it is average free process λ_{dai} of nitrogen ion. To being 10cm or more, when a pressure P is 1mTorr, when a pressure P is 10Pa (75mTorr), it is set to about 1mm. Therefore, the nitrogen ion which passes through a sheath field with the several mm sheath length L_{sh} will collide with a gas molecule (nitrogen content child) about several [an average of] times.

[0018] In practice, between the sheath length L_{sh} and a pressure P , it is $L_{sh}=bP^{-a}$ (a, b : constant, $0 < a < 0.5$).... There is a relation of (1) and the sheath length L_{sh} is not simply [since it becomes small as it becomes high / the number of times of a collision in a sheath field] in inverse proportion for a pressure P to a pressure, either.

[0019] In the anode type KAPPURUDO type plasma equipment which the cathode drop voltage VDC does not generate in a semiconductor substrate side, and the plasma treatment equipment which does not perform negative bias impression, since most constants a are 0, its sheath length L_{sh} is almost unrelated to a pressure P . Therefore, since nitrogen ion collides that a pressure P is 10Pa or more with a gas molecule about several [an average of] times in a sheath field when using these plasma equipments, many nitrogen (that is, it collides from across) ion which does not collide perpendicularly to a semiconductor substrate occurs. In this case, since the nitrogen ion which carries out incidence from across to a semiconductor substrate collides not only with the pars basilaris ossis occipitalis of a crevice but with the side attachment wall of a crevice, the nitriding reaction of the 1st electric conduction film which consists of high-melting point conductivity material formed in the side attachment wall of a crevice is promoted.

[0020] In addition, probable, if mean collisional frequency is 3 times or more, by the time most nitrogen ion reaches a semiconductor substrate, it will collide with a gas molecule once [at least].

[0021] Composition including the process which holds the aforementioned semiconductor substrate and carries out the plasma nitriding of the surface section of the electric conduction film of the above 1st is added in the aforementioned vacuum tub by which invention of a claim 2 was maintained at the composition of a claim 1, and the 3rd process of the above was maintained at the pressure of 50Pa or more.

[0022] The following phenomena occur by composition of a claim 2. That is, since the inside of a vacuum tub is held at the pressure of 50Pa or more and nitrogen ion collides with a gas molecule an average of 10 times or more in a sheath field, as for nitrogen ion, the rate which collides with a gas molecule just before colliding with a semiconductor substrate becomes very high. For this reason, although nitrogen ion is accelerated in the perpendicular direction to the semiconductor substrate in the sheath field, if it collides with a gas molecule just before nitrogen ion with the energy of the substrate perpendicular direction of a certain amount of size collides with a semiconductor substrate, the energy of an parallel direction will increase to the semiconductor substrate of nitrogen ion. Therefore, the rate of the nitrogen ion which carries out incidence at a shallow angle to a semiconductor substrate increases.

[0023] wiring [in / the 4th process of the above / to the composition of a claim 1 / in invention of a claim 3] -- public funds -- a group adds limitation that they are copper or a copper alloy

[0024] Invention of a claim 4 adds limitation that the high-melting point conductivity material in the 2nd process of the above is titanium, a tantalum, or a tungsten to the composition of a claim 1.

[0025] The composition in which invention of a claim 5 includes the process which carries out plasma nitriding to the composition of a claim 1 after the 3rd process of the above has held the aforementioned semiconductor substrate to ground potential or right potential is added.

[0026] The following phenomena occur by composition of a claim 5. That is, in the cathode KAPPURUDO type plasma equipment which the cathode drop voltage VDC generates in a semiconductor substrate side, and the plasma treatment equipment which impresses negative bias to a substrate side, nitrogen ion is accelerated with the potential more than plasma potential. In a plasma nitriding process, there is an ion-energy dependency in the angle (recoil angle) on which nitrogen ion collides with a nitrogen content child, and is scattered, and it is scattered on a large angle, so that an ion energy is small. Therefore, even if nitrogen ion collides with a gas molecule in the plasma equipment with which nitrogen ion is accelerated with the potential more than the plasma potential mentioned above, it is difficult to carry out incidence to a semiconductor substrate at the shallow angle which can nitride the 1st electric conduction film of the side-attachment-wall section of a crevice. However, if plasma nitriding is performed where a semiconductor substrate is held to ground potential or right potential, since nitrogen ion will be accelerated only with plasma potential and the recoil angle of nitrogen ion will spread, incidence of the nitrogen ion will be carried out at a shallow angle to a semiconductor substrate.

[0027] Invention of a claim 6 adds the composition that the 2nd process of the above includes the process which deposits the aforementioned metal by CVD to the composition of a claim 1.

[0028] since the process which forms the 1st electric conduction film by composition of a claim 6 is performed by CVD, the 1st electric conduction film with the coverage which resembled the pars basilaris ossis occipitalis and the side-attachment-wall section of a crevice of an insulator layer, and received and was excellent in them can be formed

[0029] Invention of a claim 7 adds composition including the process in which a part of this high-melting point conductivity material [at least] forms the electric conduction film of the above 1st in the amorphous state to the composition of a claim 6, when the 2nd process of the above deposits this high-melting point conductivity material in the temperature field in which crystallization of the aforementioned high-melting point conductivity material is suppressed.

[0030] By depositing this high-melting point conductivity material in the temperature field in which crystallization of the high-melting point conductivity material which constitutes the 1st electric conduction film is suppressed by composition of a claim 7 Since a part of this high-melting point conductivity material [at least] forms the 1st electric conduction film in the amorphous state and irregularity cannot be easily made on the front face of the 1st electric conduction film In case plasma nitriding treatment is performed to the surface section of the 1st electric conduction film and the 2nd electric conduction film is formed, the nitriding to the 1st electric conduction film progresses at an almost uniform speed.

[0031]

[Embodiments of the Invention] Drawing 1 and drawing 2 show the order cross section of a process of the embedding wiring formation method concerning 1 operation gestalt of this invention.

[0032] First, as shown in drawing 1 (a), after depositing the silicon oxide 12 of 1.5 micrometers of thickness as an insulator layer by the plasma CVD method on a silicon substrate 11, the concave slot 13 of a circuit pattern with a depth of 600nm is formed in a silicon oxide 12.

[0033] Next, it is WF6 on the titanium film 14 as shown in drawing 1 (b), after depositing the titanium film 14 of 30nm of thickness as an adhesion layer by the sputter on a silicon oxide 12. By the heat CVD using gas, the tungsten film 15 of 50nm of thickness as 1st electric conduction film which consists of high-melting point conductivity material is deposited.

Generally, as processing temperature at the time of forming a tungsten film by heat CVD, a crystal growth fully progresses and about 450 degrees C which can deposit the small film of specific resistance are adopted. However, if a crystal growth fully progresses, the irregularity of dozens of nm will arise in the front face of the tungsten film 15, and a shadow will be made to the heights bottom in the side attachment wall of the concave slot 12, in view of opening of the concave slot 12. It is desirable that perform heat CVD in the field which becomes the shadow of the heights in a side attachment wall at the temperature of about 350 degrees C in order to suppress a crystal growth, since nitriding of the tungsten film 15 does not fully progress in the case of the plasma nitriding treatment mentioned later, and a front face deposits the smooth tungsten film 15 on it.

[0034] Next, using anode distributor-shaft-coupling type plasma equipment as shown in drawing 4, as shown in drawing 1 (c), the nitrogen ion 16 is made to arrive at the front face of the tungsten film 15, and the nitriding tungsten film 17 as 2nd electric conduction film used as the barrier layer to copper is formed in the front face of the tungsten film 15. In drawing 4, it is a sample base used as the anode electrode which 20 is prepared in a vacuum tub, and 21 is prepared in the vacuum tub 20, and holds a silicon substrate 11, and this sample base 21 is grounded. Moreover, in drawing 4, 22 is a counterelectrode used as the cathode electrode prepared so that the sample base 21 might be countered, and RF power is impressed to this counterelectrode 22. Thereby, plasma occurs in the plasma field 23 between the sample base 21 and a counterelectrode 22. If the nitriding tungsten film 17 is formed using such anode distributor-shaft-coupling type plasma equipment, since cathode drop voltage does not occur in a silicon substrate 11 and a constant will almost be set to 0 in the aforementioned (1) formula, the sheath length Lsh becomes unrelated to a pressure P.

[0035] Hereafter, the processing conditions which form the nitriding tungsten film 17 in the front face of the tungsten film 15 are explained.

[0036] As processing conditions in which the nitrogen ion 16 carries out incidence in the direction of slant to a silicon substrate 11, it is the kind of gas, for example, : N2 quantity of gas flow : 100sccm pressure : 10Pa (75mTorr) RF power : 500W sample base temperature : 25-degree-C processing time : 60sec is mentioned.

[0037] Since the average free process of the nitrogen ion 16 is about 1mm when the internal pressure of the vacuum tub 20 is 10Pa, as shown in drawing 3, the nitrogen ion 16 to which sheath length passes through about 3mm sheath field collides with a nitrogen content child by an average of 3 times of frequency. Moreover, if the mean collisional frequency of the nitrogen ion 16 is 3 times or more, by the time almost all the nitrogen ion 16 reaches a silicon substrate 11, a nitrogen content child will be collided once [at least]. Thus, if the internal pressure of the vacuum tub 20 is set to 10Pa or more, in order that the nitrogen ion 16 may collide with a nitrogen content child certainly in a sheath field. Since almost all the nitrogen ion 16 carries out incidence from across to a silicon substrate 11 and comes to reach not only the pars basilaris ossis occipitalis of the concave slot 13 in the tungsten film 15 but the side-attachment-wall section, a nitriding reaction is promoted also in the side-attachment-wall section of the concave slot 13 in the tungsten film 15.

[0038] By the way, since the nitrogen ion 16 is accelerated in a sheath field, just before reaching a silicon substrate 11, the energy of a perpendicular direction is large to the silicon substrate 11. Therefore, it is desirable to collide with a nitrogen content child, just before the nitrogen ion 16 reaches a silicon substrate 11. As for the mean collisional frequency with the nitrogen content child in the sheath field of the nitrogen ion 16, for that, it is desirable that it is 10 times or more, and such processing pressure force is more than 50Pa (375mTorr).

[0039] In addition, if the processing pressure force is set to 100Pa or more, since the rate of the nitrogen ion 16 which carries out incidence at a shallow angle to a silicon substrate 11 will increase rapidly and it becomes possible to form the nitriding tungsten film 17 uniformly in all the fields containing the side-attachment-wall section in the concave slot 13 of the tungsten film 15, it is more effective.

[0040] Moreover, in the aforementioned operation gestalt, since the anode distributor-shaft-coupling type plasma equipment which does not make an ion energy larger than required is used, the recoil angle of the nitrogen ion 16 becomes large, and incidence of the nitrogen ion 16 can be carried out more in the direction of slant to a silicon substrate 11.

[0041] In order to use the processor and processing conditions which were mentioned above in plasma nitriding treatment, The tungsten film 15 with a smooth front face accumulates by the heat CVD in about 350-degree C low temperature. The nitrogen ion 16 can carry out incidence from across to a silicon substrate 11, it can be put together to collide with the side attachment wall of the concave slot 13 in the tungsten film 15 certainly, and the nitriding tungsten film 17 can be formed in the side attachment wall of the concave slot 13 certainly and uniformly.

[0042] In addition, in the aforementioned operation gestalt, since the rate of the nitrogen ion 16 which carries out incidence at a shallow angle to a silicon substrate 11 will increase as a pressure at the time of forming the nitriding tungsten film 17 if a pressure is set to 50Pa or about 100Pa although 10Pa was used, the nitriding tungsten film 17 can be formed more in the side attachment wall of the concave slot 13 at homogeneity.

[0043] Moreover, in the aforementioned operation gestalt, although plasma nitriding of the tungsten film 15 was performed using anode distributor-shaft-coupling type plasma equipment as mentioned above, even if it uses bias non-impressed ICP (capacity-coupling type plasma), a microwave plasma generator, etc., an equivalent effect is acquired. Since the energy of a direction perpendicular to the silicon substrate 11 which the nitrogen ion 16 has becomes large by the ion-energy dependency of a recoil angle, as for the cathode KAPPURUDO type plasma equipment which the cathode drop voltage VDC generates in a silicon-substrate 11 side, and the plasma treatment equipment which impresses negative bias to a silicon-substrate 11 side, avoiding is desirable. That is, it is desirable to carry out to ground the sample base 21 etc. and to accelerate ion only with plasma potential.

[0044] Next, as shown in drawing 2 (a), after depositing the copper film 18 as a metal membrane of 800nm of thickness on the whole surface by the spatter, 400-degree C heat treatment is performed in hydrogen atmosphere to a copper film 18, and a copper film 18 is slushed into the interior of the concave slot 13.

[0045] Next, chemical machinery polish removes the titanium film 14 deposited on the exterior of the concave slot 13, the tungsten film 15, the nitriding tungsten film 17, and a copper film 18, as shown in drawing 2 (b). Then, after depositing the layer insulation film which contains a silicon nitride etc. by the known method, a multilayer interconnection is formed by forming a wiring layer on this layer insulation film.

[0046] Drawing 5 shows the relation between the processing pressure force P in a plasma nitriding process, and the copper concentration diffused in the tungsten film 15, and when the processing pressure force is set to 10Pa or more, it turns out that copper concentration falls remarkably. Thereby, it has checked that the nitriding tungsten film 17 was certainly formed in the pars basilaris ossis occipitalis and the side-attachment-wall section of the concave slot 13 in the tungsten film 15. Moreover, when the processing pressure force is set to 100Pa or more from drawing 5, it turns out that about 4 figures of copper diffusing capacities can be suppressed, and the nitriding tungsten film 17 is more certainly formed in the pars basilaris ossis occipitalis and the side-attachment-wall section of the concave slot 13 in the tungsten film 15.

[0047] As mentioned above, in this operation gestalt, in a plasma nitriding process, since incidence of the nitrogen ion 16 is certainly carried out from across to a silicon substrate 11 and the side-attachment-wall section of the concave slot 13 in the tungsten film 15 is efficiently reached in order to use an aforementioned processor and aforementioned processing conditions, also in this side-attachment-wall section, the nitriding tungsten film 17 can be formed certainly. Thereby, the diffusion to the silicon oxide 12 of a copper film 18 is suppressed, and the thing to which wiring resistance does not have a bad influence on elements, such as a transistor, low and for which it embeds and copper wiring is formed becomes possible.

[0048] In addition, in the aforementioned operation gestalt, although the nitriding tungsten film 17 which serves as a barrier layer by the plasma nitriding to the tungsten film 15 was formed using a tungsten as a high-melting point conductivity material, it can replace with the nitriding tungsten film 17, other high-melting point metal membranes, such as a titanium film and a tantalum film, can be used, and barrier layers formed of the plasma nitriding to a high-melting point metal membrane besides these, such as a titanium-nitride film and a tantalum-nitride film, can also be used. Moreover, the barrier layer whose barrier nature formed of the plasma nitriding to the high-melting point electric conduction film which consists of this titanium nitride etc. improved can also be replaced with and used for the nitriding tungsten film 17, using a titanium nitride etc. as a high-melting point conductivity material.

[0049] Moreover, in the aforementioned operation gestalt, although the titanium film 14 as an adhesion layer was deposited on the silicon oxide 12 in order to raise the adhesion to the silicon oxide 12 of the tungsten film 15, when forming a titanium-nitride film as a barrier layer, the aforementioned adhesion layer may not be.

[0050] moreover, the aforementioned operation gestalt -- setting -- wiring -- public funds -- although copper was used as a group, it may replace with copper and a copper alloy, gold, or silver may be used

[0051]

[Effect of the Invention] Where the inside of a vacuum tub is held in pressure of 10Pa or more, in order to carry out the plasma nitriding of the surface section of the 1st electric conduction film according to the embedding wiring formation method concerning invention of a claim 1, Since almost all nitrogen ion collides with a nitrogen content child once [at least] in a sheath field, the direction to which almost all the nitrogen ion of the nitrogen ion which progresses perpendicularly to a sample base goes can be changed, and incidence is carried out from across to a semiconductor substrate. for this reason, since the part of the nitrogen ion which carries out incidence into the crevice of the 2nd electric conduction film reaches the side-attachment-wall section of a crevice certainly, the nitride of high-melting point conductivity material forms in the side-attachment-wall section of the crevice in the 2nd electric conduction film certainly -- having -- thereby -- wiring -- public funds -- the diffusion to the insulator layer of a group can be prevented Moreover, when an insulator layer is a silicon oxide, oxidization of the metal for wiring can also be prevented.

[0052] Since nitrogen ion collides with a nitrogen content child an average of 10 times or more in a sheath field in order to carry out the plasma nitriding of the surface section of the 1st electric conduction film according to the embedding wiring formation method concerning invention of a claim 2, where the inside of a vacuum tub is held in pressure of 50Pa or more, the rate which collides with a nitrogen content child just before nitrogen ion reaches a semiconductor substrate while the

energy of an parallel direction increases to a sample base also increases. For this reason, since incidence of the nitrogen ion is carried out with a much more big angle to a semiconductor substrate, the rate of the nitrogen ion which reaches the wall of the crevice of the 2nd electric conduction film increases, and the side-attachment-wall section of the crevice in the 2nd electric conduction film is nitrided much more certainly.

[0053] the wiring which consists of copper or a copper alloy according to the embedding wiring formation method concerning invention of a claim 3 -- public funds -- diffusion into the insulator layer of a group can be prevented

[0054] According to the embedding wiring formation method concerning invention of a claim 4, the barrier layer which consists of a nitride of titanium, a tantalum, or a tungsten can be formed.

[0055] Since incidence of the nitrogen ion is carried out at a shallower angle to a semiconductor substrate in order to perform plasma nitriding according to the embedding wiring formation method concerning invention of a claim 5, where a semiconductor substrate is held to ground potential or right potential, the 2nd electric conduction film which consists of a nitride of a more uniform high-melting point conductivity material can be formed.

[0056] Since the process which forms the 1st electric conduction film is performed by CVD according to the embedding wiring formation method concerning invention of a claim 6, the 1st electric conduction film with the outstanding coverage can be formed in the crevice of an insulator layer.

[0057] Since according to the embedding wiring formation method concerning invention of a claim 7 irregularity cannot be easily made on the front face of the 1st electric conduction film and the nitriding to the 1st electric conduction film progresses at an almost uniform speed in the plasma nitriding process over the 1st electric conduction film, the 2nd uniform electric conduction film can be formed rather than it consists of a nitride of high-melting point conductivity material.

[Translation done.]

* NOTICES *

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the cross section showing each process of the embedding wiring formation method concerning 1 operation gestalt of this invention.

[Drawing 2] It is the cross section showing each process of the embedding wiring formation method concerning 1 operation gestalt of this invention.

[Drawing 3] In the plasma nitriding process of the embedding wiring formation method concerning 1 operation gestalt of this invention, nitrogen ion is the conceptual diagram showing the state of colliding with a nitrogen content child.

[Drawing 4] It is the outline block diagram of the anode distributor-shaft-coupling type plasma equipment used for the embedding wiring formation method concerning 1 operation gestalt of this invention.

[Drawing 5] It is the property view showing the relation between the processing pressure force P in the plasma nitriding process of the embedding wiring formation method concerning 1 operation gestalt of this invention, and the copper concentration diffused in the tungsten film.

[Drawing 6] It is a cross section explaining the trouble of the conventional embedding wiring formation method.

[Description of Notations]

- 11 Silicon Substrate (Semiconductor Substrate)
 - 12 Silicon Oxide (Insulator Layer)
 - 13 Concave Slot (Crevice)
 - 14 Titanium Film
 - 15 Tungsten Film (1st Electric Conduction Film)
 - 16 Nitrogen Ion
 - 17 Nitriding Tungsten Film (2nd Electric Conduction Film)
 - 18 Copper Film (Metal Membrane)
 - 20 Vacuum Tub
 - 21 Sample Base
 - 22 Counterelectrode
 - 23 Plasma Field
-

[Translation done.]

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CORRECTION or AMENDMENT

[Official Gazette Type] Printing of the amendment by the convention of 2 of Article 17 of patent law.

[Section partition] The 2nd partition of the 7th section.

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R

[Procedure revision]

[Filing Date] April 27, Heisei 10.

[Procedure amendment 1]

[Document to be Amended] Specification.

[Item(s) to be Amended] Claim.

[Method of Amendment] Change.

[Proposed Amendment]

[Claim(s)]

[Claim 1] The 1st process which forms a crevice in the insulator layer on a semiconductor substrate.

The 2nd process which forms the 1st electric conduction film which has a crevice in the part which consists of this high-melting point conductivity material, and corresponds with the crevice of the aforementioned insulator layer by depositing high-melting point conductivity material on the aforementioned insulator layer.

The 3rd process which forms the 2nd electric conduction film which has a crevice in the part which consists of a nitride of the aforementioned high-melting point conductivity material, and corresponds with the crevice of the electric conduction film of the above 1st by holding the aforementioned semiconductor substrate and carrying out the plasma nitriding of the surface section of the electric conduction film of the above 1st into the vacuum tub maintained at the pressure of 10Pa or more.

the electric conduction film top of the above 2nd -- wiring -- public funds -- a group -- the crevice of the electric conduction film of the above 2nd -- the aforementioned wiring -- public funds -- depositing so that a group may be embedded -- the aforementioned wiring -- public funds -- the 4th process which forms the metal membrane which consists of a group

the portion located in the outside of the crevice of the aforementioned insulator layer in the electric conduction film of the above 1st, the 2nd electric conduction film, and a metal membrane -- removing -- the inside of the crevice of the electric conduction film of the above 2nd -- the aforementioned wiring -- public funds -- the embedding wiring formation method characterized by having the 5th process which consists of a group, and which embeds and forms wiring

[Claim 2] The 3rd process of the above is the embedding wiring formation method according to claim 1 characterized by including the process which holds the aforementioned semiconductor substrate and carries out the plasma nitriding of the surface section of the electric conduction film of the above 1st into the aforementioned vacuum tub maintained at the pressure of 50Pa or more.

[Claim 3] the wiring in the 4th process of the above -- public funds -- the embedding wiring formation method according to claim 1 characterized by a group being copper or a copper alloy

[Claim 4] The high-melting point conductivity material in the 2nd process of the above is the embedding wiring formation method according to claim 1 characterized by being titanium, a tantalum, or a tungsten.

[Claim 5] The 3rd process of the above is the embedding wiring formation method according to claim 1 characterized for including the process which performs plasma nitriding where the aforementioned semiconductor substrate is held to ground potential or right potential by things.

[Claim 6] The 2nd process of the above is the embedding wiring formation method according to claim 1 characterized by including the process which deposits the aforementioned high-melting point conductivity material by CVD.

[Claim 7] The 2nd process of the above is the embedding wiring formation method according to claim 6 characterized by including the process in which a part of this high-melting point conductivity material [at least] forms the electric

conduction film of the above 1st in the amorphous state by depositing this high-melting point conductivity material in the temperature field in which crystallization of the aforementioned high-melting point conductivity material is suppressed.
[Claim 8] The 3rd process of the above is the embedding wiring formation method according to claim 1 characterized by including the process which holds the aforementioned semiconductor substrate and carries out the plasma nitriding of the surface section of the electric conduction film of the above 1st into the aforementioned vacuum tub maintained at the pressure of 100Pa or more.

[Claim 9] The electric conduction film of the above 1st is the embedding wiring formation method according to claim 1 characterized by being a titanium-nitride film.

[Claim 10] The 2nd process of the above is the embedding wiring formation method according to claim 1 or 9 characterized by including the process which forms the electric conduction film of the above 1st by depositing the aforementioned high-melting point conductivity material on this titanium-nitride film, after forming a titanium film on the aforementioned insulator layer.

[Procedure revision]

[Filing Date] August 7, Heisei 10.

[Procedure amendment 1]

[Document to be Amended] Specification.

[Item(s) to be Amended] Claim 10.

[Method of Amendment] Change.

[Proposed Amendment]

[Claim 10] The 2nd process of the above is the embedding wiring formation method according to claim 1 or 9 characterized by including the process which forms the electric conduction film of the above 1st by depositing the aforementioned high-melting point conductivity material on this titanium film, after forming a titanium film on the aforementioned insulator layer.

[Translation done.]